DOCUMENT RESUME

ED 116 608 IR 002 472

AUTHOR	Swanson, James H.; And Others
TITLE	Using OMNITAB to Teach Applied Statistics.
INSTITUTION	Texas Univ., Austin. Project C-BE.
SPONS AGENCY	National Science Foundation, Washington, D.C.
REPORT NO	EP-11-5-21-73
PUB DATE	21 May 73
NOTE	20p.; For related documents see IR 002 463, 464, and 470
EDRS PRICE	MF-$0.76 HC-$1.58 Plus Postage
DESCRIPTORS	College Curriculum; *Computer Assisted Instruction; Computer Based Laboratories; *Computer Programs; Higher Education; Individualized Curriculum; On Line Systems; Program Descriptions; Statistical Analysis; *Statistics
IDENTIFIERS	*OMNITAB; Project C BE

ABSTRACT

Developed by the National Bureau of Standards, OMNITAB is a simplified computer language designed to permit the novice user to solve basic statistical functions after less than an hour of instruction. It was hoped that by providing students in introductory statistics courses with an easily understood computer language, fears of number operations would be allayed, and excitement and interest would be generated. OMNITAB can arrange data and do calculations using only a simple list of English language commands and the subsequent numbers. The program provides for immediate corrections of errant commands, and it performs such operations as matrices, linear models, regression, and analysis of variance. Students at the University of Texas easily mastered these basic operations. (EMH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED116608

USING OMNITAB TO TEACH APPLIED STATISTICS*

EP-11/5/21/73

James M. Swanson, Stephen Riederer, and Howard Weekly

Department of Psychology
The University of Texas at Austin

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

* This study was supported in part by Project C-BE under Grant GY-9340 "The Use of Computer-Based Teaching Techniques in Undergraduate Science and Engineering Education" from the National Science Foundation to the University of Texas, Drs. John J. Allan and J. J. Lagowski, Co-Directors.

IR 002 472

USING OMNITAB TO TEACH APPLIED STATISTICS

James M. Swanson, et. al.
The University of Texas at Austin

One of the most difficult problems encountered in teaching statistics in the behavioral sciences is overcoming the boredom, frustration, and fear students associate with solving problems which require a large number of mathematical operations. A computer is ideally suited for the repetitious calculations of applied statistics, either in real-world applications or in a laboratory setting, so a computerized statistics laboratory offers a solution to this problem. However, often an attempt to introduce the use of a computer in a statistics laboratory does not reduce the frustration and fear of quantitative topics experienced by behavioral science students in that setting. Rather, the frustration and fear is experienced while trying to learn a language (like FORTRAN, or to a lesser extent, BASIC) to control the computer to crunch numbers effectively. Fortunately, the National Bureau of Standards (NBS) has developed a language called OMNITAB that can be acquired easily by almost anyone, and even those without <u>any</u> prior experience with computers can use OMNITAB effectively after less than an hour of instruction and practice. The language remains sophisticated and flexible enough to be used by professional statisticians (which actually was the basic purpose behind its development).

In a previous paper (Swanson, Ledlow, and Harris, 1972), the interactive use of OMNITAB in an introductory statistics class was reported. A brief summary of that application follows:

Using OMNITAB in an Introductory Statistics Class -- A Summary

By augmenting (not replacing) classroom instruction in statistics with a computerized laboratory, we wished to attain three basic objectives. First, we endeavored to overcome the typical student's dislike or fear of handling numbers by providing the student with a "number cruncher." By showing the student how to use a computer, we tried to make handling numbers easy and enjoyable rather than frustrating. Second, by introducing the computer as a tool, we have been able to use realistic and complex laboratory problems without introducing the boredom usually associated with the mechanical operations of numerical problem solving. Third, we are striving to motivate the student by providing a new skill (the use of a computer and a little knowledge about a computer center) that will be viewed not only as immediately valuable and useful in class, but also as having potential applications outside the statistics class.

To accomplish objectives stated above, students needed to learn a language that had the following characteristics:

(1) It must be very easy to learn. This is very important, because the cost of learning some computer languages in terms of time and frustration is greater than the payoff in the statistics class.

(2) It must perform all the necessary operations for solving complex as well as simple statistical problems.

(3) It must be useful for a variety of problems that students (especially graduate students) encounter outside the classroom in which use of a digital computer would be beneficial.

(4) It must be widely available rather than unique to the University of Texas campus.

The language we chose to use is called OMNITAB. OMNITAB is an interpretive computing system that enables the non-programmer to use a large digital computer to perform a large variety of calculations and manipulations on tabulated data without any prior knowledge of computers or of computer languages. The OMNITAB master program consists of a set of 177 FORTRAN subprograms which interpret and execute instructions written in the form of simple English sentences. To understand how OMNITAB works, it is helpful to imagine a large worksheet having 50 rows and 20 columns. (The dimensions of the worksheet in OMNITAB are variable and may be set by the user.) OMNITAB instructions are used to put data into the columns of the worksheet, to calculate using the data, to rearrange the data, and to output the data in various ways. Only the initial word (a command) and the subsequent numbers (arguments) of an OMNITAB instruction are used by the master program, so descriptive comments may be included to aid in understanding the meaning of the instruction. Instructions are executed as they are encountered.

Free formatted input and output and a very simple set of basic instructions make basic OMNITAB as easy to master as a modern hand calculator. The use of these instructions can be demonstrated by the following example: To get data into the worksheet, one merely tells the computer

SET the following numbers into col 1

and follows the statement with numbers placed anywhere on the card. Commands like ADD, SUBTRACT, MULTIPLY, DIVIDE, SUM, AVERAGE, SQUARE, ORDER, SORT, etc., can be used to perform calculations and to manipulate the data in the worksheet. A simple example is:

SUM the numbers in col 1 and put the answer in col 2

To print data stored in the worksheet, one merely says:

PRINT the data stored in col 1 and in col 2

A set of higher order commands (HISTOGRAM, STATISTICAL ANALYSIS, CORRELATION, FIT (least squares regression), ANALYSIS OF VARIANCE, etc.) provide statistical packages designed to handle commonly encountered statistical problems. A complete set of instructions and a description of the OMNITAB system are given in the National Bureau of Standards Handbook 552, OMNITAB II--A User's Reference Manual, by Hogben, Peavey, and Varner. The Handbook may be obtained from the Government Printing Office for $2.00.

Examples of Laboratory Use of OMNITAB by Beginners

A beginning OMNITAB programmer is reminded that each instruction is executed as it is encountered and interpreted, so the order of instructions controls the flow of computations in the same way that hand calculations are

performed and recorded in a multi-columnar pad. Students are encouraged to write out the steps of a desired calculation in simple English sentences and then the list of sentences is taken as the OMNITAB program. For example, the steps for calculating the variance of a set of numbers are:

SUM the numbers

DIVIDE by N

SUBTRACT the mean from each number

SQUARE the resulting deviation scores

SUM the squared deviations

DIVIDE by N - 1

If the concept of a worksheet is added to keep track of the numbers, then the OMNITAB program is complete. To illustrate the use of basic OMNITAB, the instructions and a portion of a laboratory problem are presented in Table 1. (See Swanson, Ledlow, & Harris, 1973 for a complete solution.)

TABLE 1

An example laboratory exercise. Lab 1: Using OMNITAB to calculate summary statistics. The lines below enclosed in quotation marks were entered by the student; the other lines were initiated by the computer.

"BLOWUP, MARY Q. STUDENT." This command labels subsequent remote output with S's name.

"EXECUTE lab 1"

INSTRUCTIONS

THE 91 X AND Y SCORES GIVEN ON P. 100 OF "BASIC STATISTICS" BY W. L. HAYS ARE STORED ON MAGNETIC TAPE. USE THE FOLLOWING OMNITAB INSTRUCTIONS TO READ THESE DATA INTO THE OMNITAB WORKSHEET.

```
FORMAT B (F2.1, F3.0)
REWIND TAPE A
CREAD TAPE A B FORMAT 91 X AND Y SCORES INTO COLS 1 AND 5
```

AFTER YOU OBTAIN THE DATA, CALCULATE THE MEAN, VARIANCE, AND THE STANDARD DEVIATION FOR EACH SET OF SCORES. THEN USE THE "FREQUENCY" AND "HISTOGRAM" COMMANDS TO PRINT OUT FREQUENCY DISTRIBUTIONS ACCORDING TO YOUR OWN SPECIFICATIONS.

BEGIN YOUR OMNITAB PROGRAM.

```
"DIMENSION the worksheet 100 rows by 10 cols"
    READY
"FORMAT B(F2.1,F3.0)"
    READY
"REWIND TAPE A"
    READY
"CREAD TAPE A B format 91 X's and Y's into columns 1 and 10"
    READY
"SUM the X scores in col 1 and put the answer in col 2"
    READY
"DIVIDE the sum in col 2 by n = 91.0 and put the mean back in col 2"
    READY
"SUBTRACT the mean in col 2 from each score in col 1"
    ***command rejected, reenter
    *** 2 is an illegal number of arguments
```

```
"SUBTRACT the mean in col 2 from X's in col 1 and put answer in col 6"
    READY
"SQUARE the deviation scores in col 3 and put the sqred devs in col 3"
    READY
"SUM the sqred devs in col 3 and put the answer back in col 3"
    READY
"DIVIDE col 3 by 90.0 and put the average squared dev in col 3"
    READY
"SQRT of the variance in col 3, put the answer (std dev) into col 4"
    READY
"NOTE      MEAN              VAR              STD DEV "
    READY
"ABRIDGE row 1 of cols 2, 3, and 4"
          4.1978011      3.0158193      1.7366115
```

The student continues working to obtain the rest of the solution for this laboratory problem.

This laboratory problem was assigned to 50 undergraduate students (mostly sophomore Psychology and Nursing majors) in an introductory statistics class. These students had completed a week of class during which the topics of frequency distributions and summary statistics were covered in lecture and in the assigned chapters in the text. All except 5 students were completely naive in regard to computer use or computer languages. A short (30 minute) description of how OMNITAB works was given in class, and students were given a copy of the basic set of instructions to be used.

We were surprised to find that every student used OMNITAB effectively during this first session. Most students made mistakes entering OMNITAB commands, but the error messages which immediately follow improper instructions allowed the student to make self-corrections. This immediate feedback aspect of OMNITAB makes the language almost self-teaching. The first 5 students on the terminals needed aid from the lab supervisor to get started; subsequently, students watched the preceeding user, and this acquired familiarity resulted in very few appeals to the supervisor for aid. A few complaints were voiced, mostly concerning slow response time on the time-sharing system, but almost all of the students seemed to enjoy the lab.

In the previous paper, two modifications of OMNITAB were discussed: (1) an alteration that makes OMNITAB interactive under the TAURUS time-sharing system at the University of Texas, and (2) the addition of initialization routines that automatically provide a student with a set of instructions,

programs prepared by the instructor, and data from an external source (cards or magnetic tape). Cost estimates (about $ .40 per student for each lab) were also discussed.

A New Application of OMNITAB for Pedagogical Purposes

OMNITAB has been demonstrated to be an effective teaching device when the students in the class are unfamiliar with both statistics and computers. The application to be described in this paper was in a more advanced statistics course in which the students were already familiar with the basic concepts in inferential statistics, but were unfamiliar with the use of a computer. The course emphasized linear models, regression, and analysis of variance (ANOVA), and the use of the computer was felt to be necessary for the students to learn and apply the material covered.

Six laboratory exercises were developed to supplement classroom instruction and homework problem assignments, and the lab topics are listed below:

(1) Introduction to OMNITAB

(2) Introduction to Matrix operations

(3) The Design Matrix in ANOVA

(4) Obtaining predicted scores and estimating error variance

(5) Comparing alternative models

(6) Using the FIT command of OMNITAB and interpreting its auto-output.

This set of laboratories was developed and used in a class of 35 upper-division undergraduates and first year graduate students. Each laboratory was designed to take a prepared student less than 20 minutes to complete, and each laboratory session was discussed briefly in class before it was to be executed to insure preparedness. A description of a portion of each laboratory follows.

(1) Introduction to OMNITAB. This laboratory was taken from an introductory statistics class, and a typical student's lab work is given in Table 1. The purpose of this lab was to review basic material and to introduce basic OMNITAB commands during this review session.

(2) Introduction to Matrix Operations. During this lab session, students were required to add, subtract, multiply, invert, and transpose matrices. A class period preceeding the lab was devoted to basic matrix operations, and the purpose of this lab was to give directed practice using the concepts covered in class. The major portion of the lab involved finding an inverse of a matrix using row operations. The portion given below was designed to give practice on matrix addition and transposition. The partial output given for this and subsequent labs follows the same format used in Table 1.

"EXECUTE lab 2"

INSTRUCTIONS

TWO 10 x 10 MATRICES (A AND B) ARE STORED IN THE WORKSHEET. MATRIX A IS IN COLS 1 THRU 10 AND ROWS 1 THRU 10, AND MATRIX B IS IN COLS 11 THRU 20 AND ROWS 1 THRU 10. FIND C = A + B AND D = A' + B'.

START YOUR OMNITAB PROGRAM

READY
"MTRANSPOSE matrix A (R1,C1), size 10 x 10, put in R11,C1"
READY
"MTRANSPOSE matrix B in row 1, col 11, size 10 x 10, put in 11,11"
READY
"MADD A in R1,C1, S = 10 x 10, and B in R1,C11, put in R1,C21"
READY
"MADD A' in 11,1, size 10 x 10, and B' (11,11) and put D in row 11,C21"
READY
"MPRINT matrix A (1,1) size 10 x 10"

This command would produce the printing of a 10 x 10 table. Subsequent print statements would be executed to print matrices B, A', B', C, and D.

(3) The Design Matrix in ANOVA. A lecture on design matrices preceeded this laboratory. The purpose of this lab was to encourage students to think about ANOVA using matrix notation.

"EXECUTE lab 3"

INSTRUCTIONS

THE DATA VECTOR (Y) FROM MENDENHALL (1968) p. 154 IS STORED IN COL 1 ROWS 1 THRU 8. THE DESIGN MATRIX (X) GIVEN THERE IS STORED IN COLS 2 THRU 6, ROWS 1 THRU 8. FIND X'Y, X'X, AND $(X'X)^{-1}$. YOU WILL USE THE RESULTS OF THIS LAB IN THE NEXT LAB PROBLEM.

START YOUR OMNITAB PROGRAM

```
    READY
"MPRINT M(1,1) size 8 x 6"

          3    1   -1   -1    1   -1

          5    1   -1    1   -1   -1

          7    1    1   -1   -1   -1

          4    1    1    1    1   -1

          5    1   -1   -1    1    1

          8    1   -1    1   -1    1

          9    1    1   -1   -1    1

          5    1    1    1    1    1

    READY
"MTRANSPOSE M(1,2) size 8 x 5 to (1,11)"
    READY
"MMULTIPLY M(1,11) size 8 x 5 by M(1,1) size (8 x 1) put in R1,C20"
    READY
"HEAD C 20/X'Y = SUM MTRX"
    READY
"PRINT col 20"

                    X'Y = SUM MTRX

                      46
                       4
                      -2
                     -12
                       8

    READY
"MMULTIPLY M(1,11) size 5 x 8 by M(1,2) size 8 x 5, put in R1,C21"
    READY
"MINVERT M(1,21) size 5 x 5, put inverse in R1,C26"
    READY
```

The student would continue and use the print commands to print out the rest of the results (X'X and $(X'X)^{-1}$). Following this

portion of the lab, students were asked to write the design matrix appropriate for the problem on P. 403 of Hays (1963), and to perform the same operations on it.

(4) Obtaining Predicted Scores and Estimating Error Variance.

This laboratory is a continuation of the previous laboratory.

The instruction for the lab provides a clear description of

its purpose.

"EXECUTE lab 4"

INSTRUCTIONS

USE $(X'X)^{-1}$ and X'Y FROM LAB 3 (WHICH ARE STORED IN COLS 1***6) TO FIND $B = (X'X)^{-1} X'Y$. THEN USE X (IN COLS 7***11) AND B TO FIND THE PREDICTED SCORE, P = XB. (THE CORRECT ANSWERS ARE IN COLS 25 AND 26.) NEXT USE THE FOLLOWING TWO METHODS TO FIND SSE: SSE = (Y - P)' (Y - P) AND SSE = Y'Y - B'X'Y. THE Y VECTOR IS IN COL 12.

START YOUR OMNITAB PROGRAM

```
    READY
"MMULTIPLY M91,1) size 5 x 5 by M(1,6) size 5 x 1, put B in R1,C21"
    READY
"MULTIPLY B(1,21) size 5 x 1 by X(1,7) size 8 x 5, put in R1,C22"
    READY
"HEAD col 21 / B = B   WTS"
    READY
"HEAD col 22 / P = PREDICTED"
    READY
"HEAD col 12 / y = OBSERVED"
    READY
"PRINT cols 21 12 22"
```

B = B WTS	Y = OBSERVED	P = PREDICTED
5.750000	3.0000	3.00000
.5000000	5.0000	5.50000
- .2500000	7.0000	7.00000
-1.500000	4.0000	3.50000
1.000000	5.0000	5.00000
.0	8.0000	7.50000
.0	9.0000	9.00000
.0	5.0000	5.50000

The student would continue with this set of data to find SSE and then start working on the second set of data from Hays.

(5) Comparing Alternative Models. In this lab, the SSE is compared for two different models for the problem on p. 403 of Hays, one containing parameters for the grand mean and the main effects, the other containing parameters for the grand mean, main effects, and interaction effects. Then students were directed to find estimates of variance,

$$MS_{interaction} = (SSE_1 - SSE_2) / (df_1 - df_2) \text{ and } MS_{error} = SSE_2 / df_2$$

to be used to obtain the F value for testing the interaction.

(6) Using the FIT Command of OMNITAB and Interpreting the Auto-Output. Part of the auto-output of the FIT command (which is described on p. 140-144 of NBS Handbook 552) is an ANOVA table. In this lab, students construct an ANOVA table using the methods practiced in labs 1 thru 5, and compare the constructed table to the table given by the FIT command.

Discussion

Classroom activity, supplemented by an OMNITAB laboratory (OMNILAB), has become the permanent format of several statistics courses offered in the Psychology Department at The University of Texas at Austin. The course has been well received by students, and some comments for a class evaluation by students in recent classes (summer, 1972) are given below.

"Considering that my mathematical background was extremely poor, I got a surprising amount from the course."

"I liked learning to program, and I am sure it will be useful to know how later on in my graduate program."

"OMNITAB was an interesting intellectual exercise and may come in handy for future research."

"I think the experience with the programs was extremely useful."

"The computer labs were by far the most valuable part of the course."

The question "I feel that I profited from the laboratory (or discussion section) for this course" is included on all course evaluations at The University of Texas at Austin. During the summer of 1972, 52 students (about half undergraduates) evaluated courses in which OMNILAB was used. The frequency distribution for answers to this question is presented below:

DEFINITELY YES	YES	UNCERTAIN	NO	DEFINITELY NO
20	21	4	3	0

In a comparison with other courses at The University of Texas at Austin, 86% ranked lower than the present course on laboratory evaluation.

The students who take the intermediate statistics course (in which the 6 lab sequence described in this paper was used) are typically completely unfamiliar with the use of a computer, matrix algebra, and linear models at the beginning of the course. However, all students use OMNITAB effectively during the first laboratory and, during later labs, they demonstrate not only the ability to manipulate matrices, but also a basic understanding of the relationship between ANOVA and linear regression. The authors feel that this performance fulfills the purpose of this module of the course, and that the use of OMNITAB is instrumental in the attainment of these goals.

In summary, the major benefits derived from using OMNILAB in a statistics class are listed below:

(1) It introduces the student to the computer center and dispels many misconceptions of what a computer does.

(2) Students like it. It motivates students in a somewhat unexciting class because they are introduced to the computer center and to one use of a computer.

(3) It gives the student a useful skill (programming with OMNITAB) that can be used outside the statistics class.

(4) It makes obtaining data and handling numbers easy. This reduces frustration, fear, and boredom usually experienced in statistics

laboratory. Also, realistic statistical problems rather than trival ones can be used in laboratory exercises.

(5) It aids the instructor in introducing difficult material (matrix algebra and ANOVA using the regression approach) by providing a means for students to practice and apply the concepts covered in the classroom.

REFERENCES

Harris, Scott, U. T. OMNITAB II, Version 5.0: User's Reference Manual Supplement. Austin, Texas: University of Texas, Computation Center, TPB-132, 1971.

Hays, William L. Statistics for Psychologists. New York: Holt, Rinehart, and Winston, 1963.

Hays, William L. Basic Statistics. Belmont, California: Brooks/Cole Publishing Company, 1969.

Hogben, D., Peavy, S., and Varner, R. OMNITAB II: User's Reference Manual. (National Bureau of Standards, Technical Note 552). Washington, D.C.: US Government Printing Office, 1971.

Mendenhall, W. Introduction to Linear Models and the Design and Analysis of Experiments. Belmont, California: Wadsworth Publishing Company, 1968.

Swanson, J. M., Ledlow, A. S., and Harris, G. S. "Using OMNITAB Interactively in a Statistics Laboratory," Behavioral Research Methods and Instrumentation. In press. (Presented at the Second Annual Conference on the Use of On-Line Computers in Psychology, St. Louis, November, 1972.) (A Project C-BE Publication, EP-9/4/2/73)